



**Barcelona  
Supercomputing  
Center**  
Centro Nacional de Supercomputación



# Air quality modelling at BSC and contribution to the Copernicus Atmosphere Monitoring Service activities

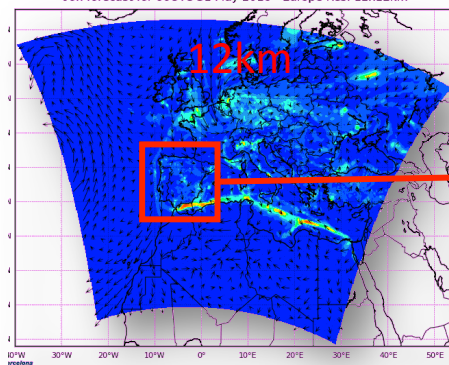
*Oriol Jorba*, Sara Basart, Jaime A. Benavides, Francesco Benincasa, Dene Bowdalo, Enza Di Tomaso, Jerónimo Escribano, María Gonçalves, Marc Guevara, Elina Karnezi, Martina Klose, Francesca Macchia, Gilbert Montané, Miriam Olid, María Teresa Pay, Herve Petetin, Daniel Rodríguez, Albert Soret, Carles Tena, Carlos Pérez García-Pando

Earth Sciences Department

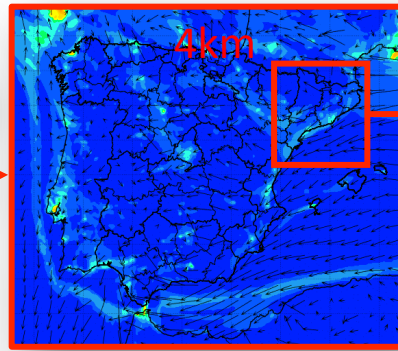
10/7/2020

FIRST on line JOINT USER FORUM ITALY-SPAIN

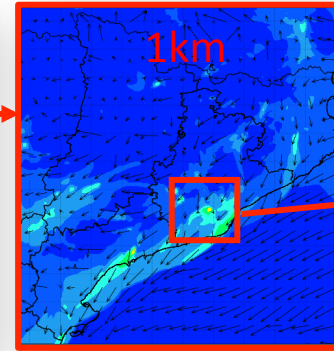
# Air Quality modelling at BSC



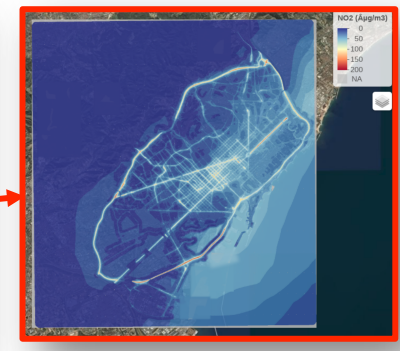
Pay et al. (2011; 2012 AE)



Baldasano et al. (2012 AE)



Pay et al. (2014 GMD)



Benavides et al. (2019 GMDD)

CALIOPE system: air quality forecasts from regional to local scales

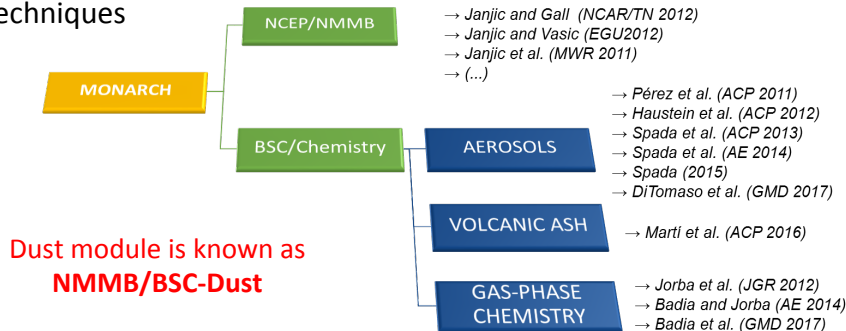
## In-house model developments



### MONARCH model

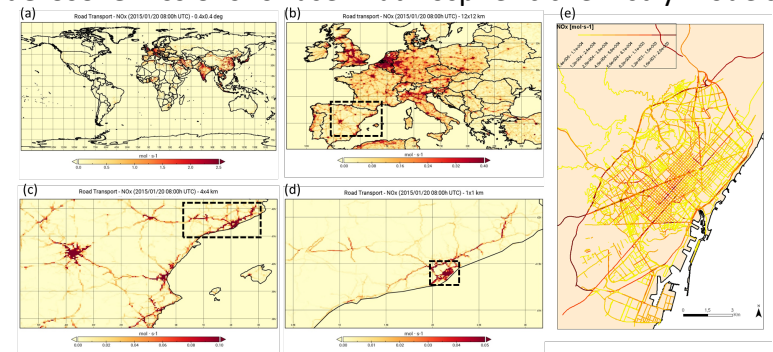
#### Multiscale Online Nonhydrostatic Atmosphere Chemistry model

- **Multiscale:** global to regional (up to 1km) scales allowed
- Fully **on-line** coupling: weather-chemistry feedback processes allowed
- Enhancement with a **data assimilation** system and machine learning techniques



### HERMESv3 emission model

A **python-based, open source, parallel and multiscale** emission modelling framework that **processes and estimates gas and aerosol emissions** for use in atmospheric chemistry models.



Guevara et al. (2019, 2020)

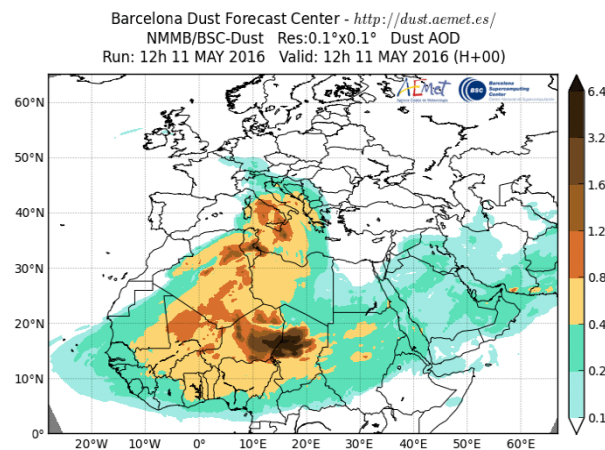
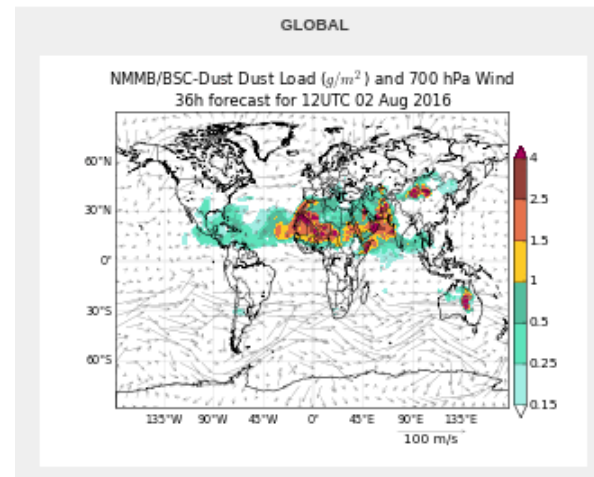
# Mineral Dust Services at BSC

## BSC dust operational forecast:

- Contribution to the SDS-WAS (regional) and ICAP (global) multi-model ensembles

## WMO Dust Regional Centres:

- **Barcelona Dust Forecast Centre.** First specialized WMO Centre for mineral dust prediction. Started in 2014 - **Operational**
  - <http://dust.aemet.es>
  - @Dust\_Barcelona
- Sand and Dust Storms Warning Advisory and Assessment System (**SDS-WAS**). North Africa, Middle East and Europe Regional Center. Started in 2010 – **Research**
  - <http://sds-was.aemet.es>
- Both WMO Regional Centres are jointly managed by BSC and AEMET





## Contributions to CAMS

**CAMS\_50**

Regional production

**CAMS\_81, CAMS\_COP\_066**

Global & regional emissions

**CAMS\_43, CAMS\_61**

Aerosol aspects and data assimilation

**CAMS\_84, CAMS\_61**

Global & regional a posteriori  
validation

**CAMS\_95**

AsSIST: Aircraft Support &  
Maintenance Services

## Associated Developments & Activities

Development of a  
multiscale modeling and forecasting systems

**MONARCH, SDS-WAS, CALIOPE, ICAP**

Development of top down and bottom up  
emission inventories and models

**HERMES**

Model data assimilation

**LETKF DA system**

Model Evaluation

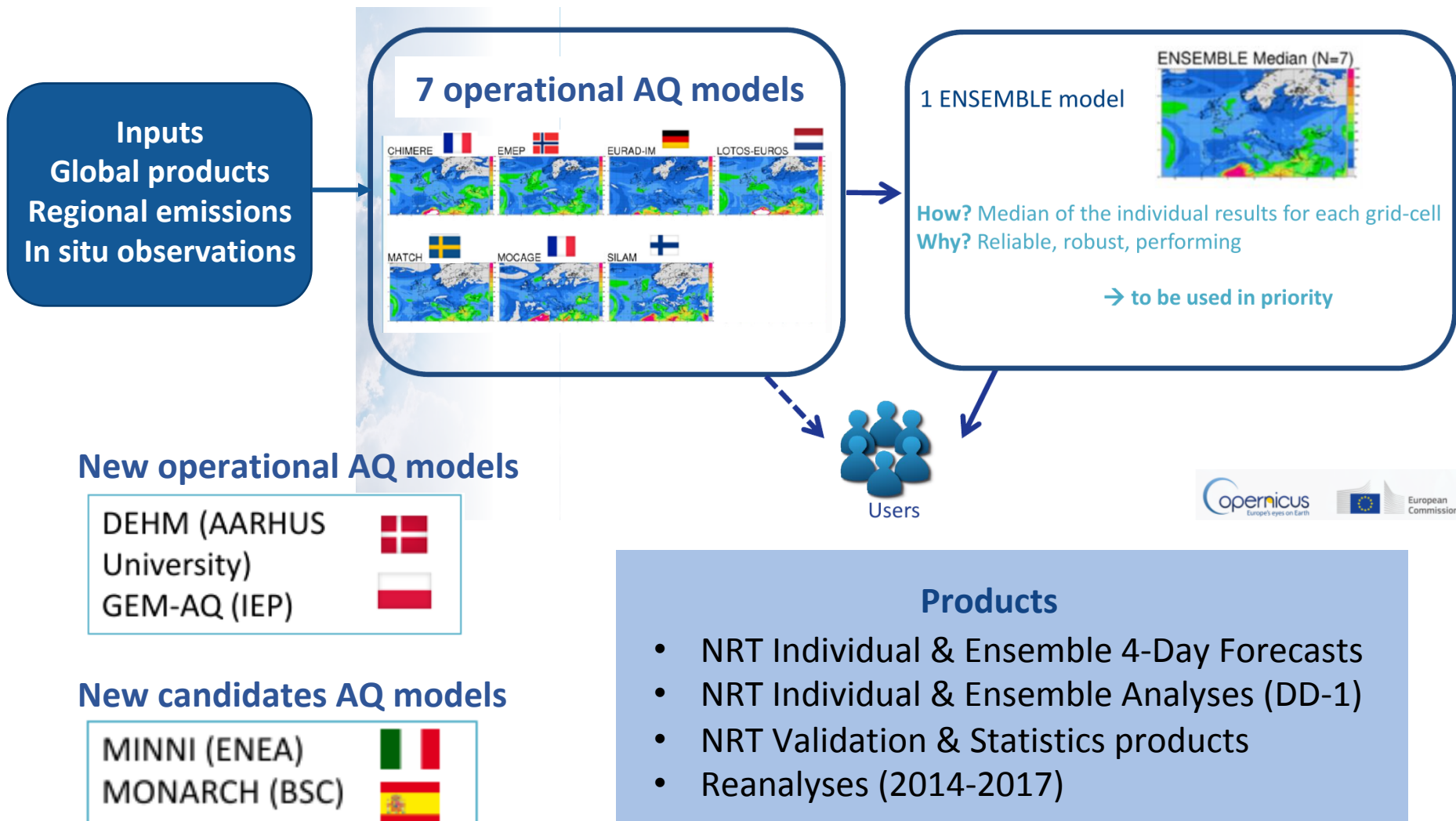
**BSC model evaluation tool and  
harmonisation of observational dataset**

Development of *user-oriented* services for a variety  
of socio-economic sectors

**InDust, DustClim, SOLWATT, AQ-WATCH**



# CAMS\_50: Regional production



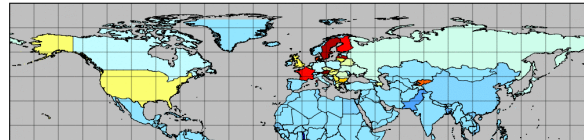
# CAMS\_81: global and regional emissions

**Objective:** To provide gridded distributions of annual anthropogenic (global and Europe) and natural emissions and deliver **monthly, weekly and diurnal temporal profiles**.

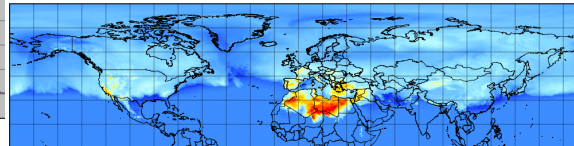
- Sources (energy and manufacturing industry, residential combustion, traffic and agriculture)

## Monthly, daily, weekly and hourly profiles

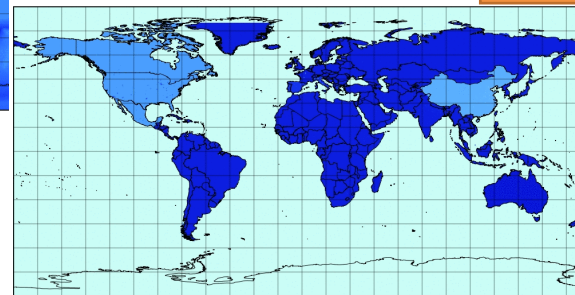
Gridded monthly weights for energy NOx emissions



Gridded daily weights for NOx residential

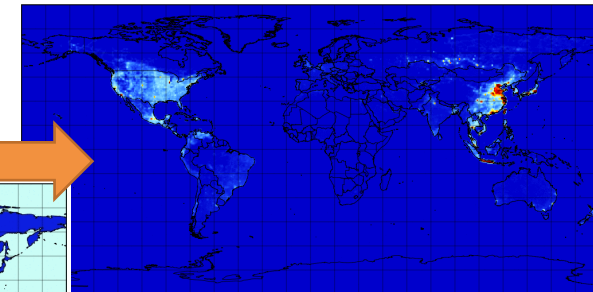


Gridded hourly weights for transport emissions  
Time: 0



Hourly factors

## Hourly emissions

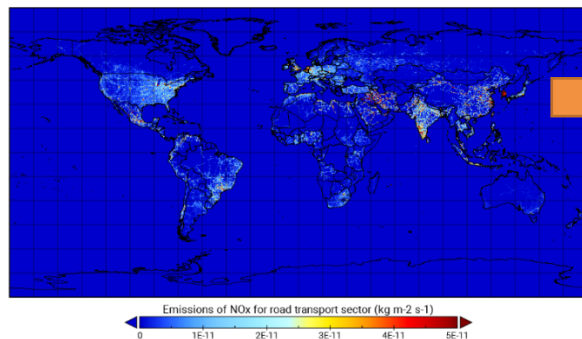


nitrogen oxides ( $\text{m}^2 \cdot \text{s}^{-1} \cdot \text{mol}$ )  
0.0E+00 1.0E-09 2.0E-09 3.0E-09 4.0E-09 5.0E-09

- Pollutants ( $\text{NO}_x$ ,  $\text{CO}$ , NMVOC,  $\text{NH}_3$ ,  $\text{SO}_x$ ,  $\text{PM}_{10}$ ,  $\text{PM}_{2.5}$ ,  $\text{CO}_2$  and  $\text{CH}_4$ )

## Annual emissions

CAMS GLOB ANT NOx road transport 2018

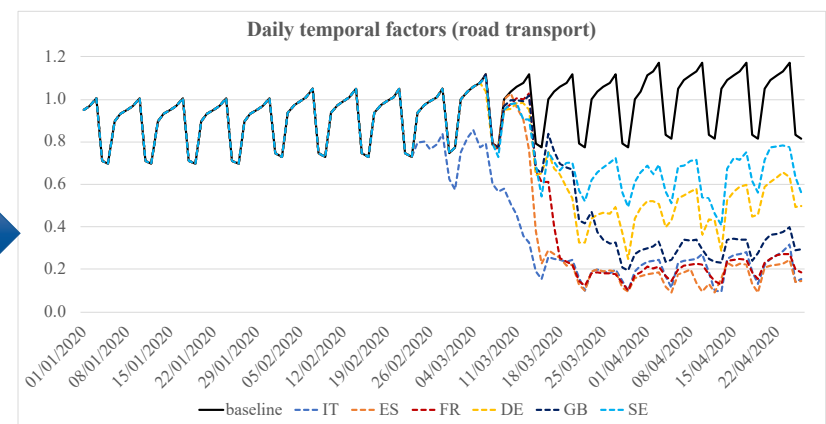
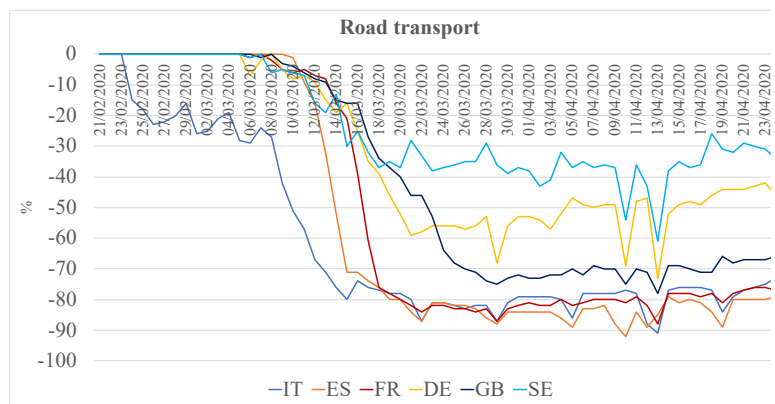


Emissions of NOx for road transport sector ( $\text{kg} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$ )  
0 1E-11 2E-11 3E-11 4E-11 5E-11

# CAMS\_COP\_066: Development of European emissions during the COVID-19 lockdown period

**Objective:** To develop daily, sector and country dependent emission reduction factors that can be combined with CAMS emissions for air quality modelling

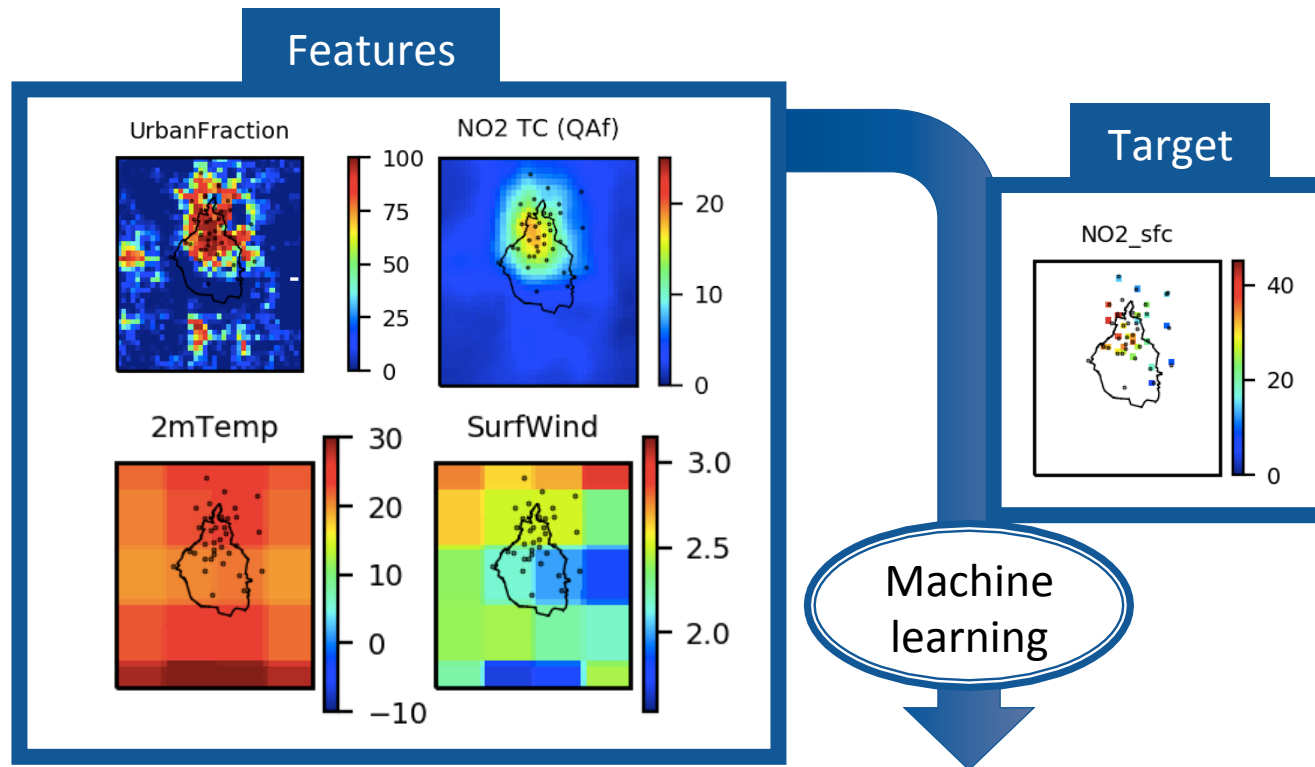
**General approach:** Compilation of measured activity data from multiple sources (e.g. Google movement reports, ENTSO-E, FlightRadar24 airport statistics). Use of meteorology + Machine Learning to derive BAU scenario for electricity demand.





# Inference of surface NO<sub>2</sub> concentrations

**Objective:** to estimate surface NO<sub>2</sub> concentrations in megacities using machine learning and open-access global Copernicus (TROPOMI, Copernicus Land Monitoring Service high resolution land cover, CAMS) and ECMWF (ERA5) products





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**AXA**  
Research Fund

# Thanks!



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